Third United Nations International Conference on the Peaceful Uses of Atomic Energy

A/CONF.28/A/9
CANADA
February 1964
Original: ENGLISH

Confidential until official release during Conference

Abstract

NPD START-UP, REACTIVITY BALANCE AND FUEL MANAGEMENT

J.W. Hilborn, W.M. Barss, M.F. Duret,
Chalk River Nuclear Laboratories,
Atomic Energy of Canada Limited, Chalk River, Ontario

J.R. Dickinson, A.C. Whittier,
Canadian General Electric Company Limited, Peterborough, Ontario
and
E. Horton,
NPD Generating Station,
Hydro Electric Power Commission of Ontario, Rolphton, Ontario

1. NPD is a 20-MW(e) power reactor, and is moderated and cooled by heavy water. It has horizontal pressure tubes containing nine 19-element UO_2 fuel bundles in each of 52 central channels, and nine 7-element bundles in each of 80 outer channels. As there are no absorber rods for reactivity control, and as full power cannot be obtained at low moderator level, 62 of the 19-element bundles were partially depleted in the fissile isotope to reduce the initial excess reactivity.

2. With all fuel in position, criticality was approached by raising the moderator level, and the initial critical height was compared with that calculated by two-group neutron-diffusion theory. The reactivity effect as the moderator level rises from the initial critical height to the top of the tank was measured by adding known amounts of $CdSO_4$ to the coolant; the total observed change in the effective multiplication constant, k_{eff}, was 0.04 and this agrees with the calculated value for the cold, clean reactor. The moderator-temperature coefficient for k_{eff} between 21°C and 74°C was found to vary from -125×10^{-6} $degC^{-1}$ at minimum moderator height to -74×10^{-6} $degC^{-1}$ at maximum height, with fresh fuel. The coolant-temperature coefficient was -36×10^{-6} $degC^{-1}$.

3. When the reactor was first operated at high power, the power coefficient of k_{eff} was found to be -31×10^{-6} per 1% change from full power. Further measurements of the power and temperature coefficients during the first 220 full-power days indicate that all three coefficients became significantly less negative with the build-up of plutonium in the core. Excluding xenon and samarium effects, the change in k_{eff} on going from zero to full power was observed to be -0.013 with fresh fuel, compared to an estimated -0.004 at equilibrium. The xenon and samarium loads at equilibrium irradiation are calculated to be 0.024 and 0.009

respectively. The initial excess reactivity available for fuel burn-up was 0.023 in k_{eff}.

4. Other measurements in NPD include the reactivity worths of the ^{235}U-Al 'booster rod' and the H_2O reflector. Radial flux distributions were measured, and compared with two-group diffusion calculations. The photoneutron source measured after an extended shutdown was in satisfactory agreement with calculation. Measurements of the reactivity effect of H_2O in D_2O moderator also confirmed calculated values.

5. The reactor is designed to operate continuously at high power, without having to shut down for fuel shifts. Principles of fuel management, for controlling both the flux distribution and the reactivity, have been determined by computer simulation of reactor behaviour under various fuelling schemes. The two-dimensional program, STOKE, for this study assumes cylindrical symmetry, but allows for the fuelling of alternate channels from opposite ends of the reactor. A three-dimensional program, PERIGEE, has been used to simulate the operating history of the reactor to date, taking changes in moderator level and purity into account as well as all fuel shifts. The calculated distribution of power among the channels agrees with the measured distribution, within the accuracy of the reactor instruments. STOKE and PERIGEE have also been used to estimate equilibrium fuel burn-up, giving an average exit irradiation exceeding 6000 MWd/tonne U.